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Interconnect Routing For A Head Gimbal Assembly

by

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Related Applications

This application claims priority of United States provisional application Serial Number 60/409,889, filed September 11, 2002, entitled "Interconnect Routing For A Head Gimbal Assembly".

Field of the Invention

The present invention relates to suspension assemblies for supporting a head in disc drives, and more particularly to an apparatus to reduce windage-induced vibration of the head by routing an interconnect assembly along a leading edge of the suspension assembly.

Background of the Invention

In a disc drive system, air currents are induced when one or more discs are rotating at high speeds. Air currents, or windage, cause undesirable effects, such as vibration in system components. Such vibration is undesirable because it can introduce errors in the performance of the disc drive. One component that is adversely affected by this windage-induced vibration is the suspension assembly. The suspension assembly is used to support/suspend a read/write head, and is mated with an interconnect assembly, which is used to electrically connect the read/write head to disc drive electronics that are positioned away from the read/write head and off the suspension assembly.

One type of interconnect assembly is a flex-on suspension, or flex circuit. Flex circuit interconnect assembly includes a separately fabricated printed circuit that is typically mounted to the suspension assembly using an adhesive after assembly of the other suspension components. The flex circuit is relatively less expensive and easier to manufacture than the other types of interconnect assemblies.

Other types of suspension interconnect assemblies include twisted wires, trace suspension assemblies, and circuit integrated suspension assemblies. Twisted wire

assemblies include a bundle of wires that are glued to the suspension assembly. A trace suspension assembly includes a unitary steel gimbal with electrical traces welded to the suspension assembly. A circuit integrated suspension assembly deposits traces directly onto the suspension assembly by a sputtering or like deposition process.

In general, the flex circuit is mated to a finished suspension assembly. The flex circuit is compliant along its entire length. The head and center portions of the flex circuit are typically attached to the suspension. However, the tail portion of the flex circuit is generally not attached to the suspension and hangs freely or is attached with tabs extending outward from a side of the suspension along a length of the base plate of the suspension. Thus, the tail portion is typically susceptible to windage forces present in the disc drive assembly that then translates to undesirable vibrations in the suspension assembly.

As the data density on the disc is continually increasing, it becomes more critical to eliminate or reduce factors that introduce error into the head reading and writing data. Since vibration of the suspension assembly is one factor that affects the operation of the head, a need exists for reducing windage-induced vibration of the head caused by the suspension assembly.

Summary of the Invention

Against this backdrop the present invention has been developed. In one example embodiment, the invention is directed to an apparatus for reducing windage-induced vibration in a disc drive having a rotating disc, wherein the disc has an inner and an outer diameter. The load beam includes a trench arrangement and flexible circuitry is housed within the trench. The apparatus may also include a plate that cooperates with the load beam to hold the flexible circuitry in the trench.

Another example embodiment is directed to a suspension assembly configured to reduce windage-induced vibration in a head supported by the suspension assembly. The system includes a base plate and a load beam mounted to the base plate. The load beam may have length and may include a laminate material. The laminate

material of the load beam may include a bottom layer, a top layer, and a core layer positioned between the top and bottom layers. The load beam may further include a trench formed in the laminate material that extends along at least a portion of the length of the load beam. The assembly may also include an interconnect circuit mounted to the load beam in at least a portion of the trench.

Another aspect of the invention relates to a method of forming a suspension assembly that is resistant to windage-induced vibrations. The suspension assembly may include a load beam constructed of a laminate material and having a length, an interconnect circuit, and a base plate. Steps of the method may include etching layers of the laminate material and assembling the etched layers into a composite material. The assembled layers may define a trench that extends along a portion of the load beam length. Further steps may include securing a first portion of the interconnect circuit in the trench, and mounting the load beam to the base plate so that the first portion of the interconnect in the trench is positioned between the load beam and the base plate.

These and various other features as well as advantages which characterize the present invention will be apparent from a reading of the following detailed description and a review of the associated drawings.

Brief Description of the Drawings

FIG. 1 is a top perspective view of a disc drive in a cover of the disc drive has been removed to show various features of the disc drive in which embodiments of the present invention may be practiced.

FIG. 2 is a plan view of a disc drive system incorporating an example embodiment of a suspension assembly mated to an interconnect assembly according to the present invention.

FIG. 3 is a plan view of the suspension assembly shown in **FIG. 2**.

FIG. 3A is a section view along line **3A-3A** of **FIG. 3**.

FIG. 3B is a plan view of the top layer of the suspension assembly of **FIG. 3**.

FIG. 3C is a plan view of the core layer of the suspension assembly of **FIG. 3**.

FIG. 3D is a plan view of the bottom layer of the suspension assembly of **FIG. 3**.

FIG. 3E is a plan view of the interconnect circuit of the suspension assembly of **FIG. 3**.

FIG. 3F is a plan view of the base plate and PZTs of the suspension assembly of **FIG. 3**.

FIG. 4 is a process flow diagram of an example embodiment of a method of making an interconnect assembly of the present invention according to the present disclosure.

FIGs. 5A-5F are perspective views of the components being assembled according to the process flow diagram of **FIG. 4**.

Detailed Description

In the following description of preferred embodiments of the present invention, reference is made to the accompanying drawings that form a part hereof, and in which is shown by way of illustration specific embodiments in which the invention may be practiced. It is understood that other embodiments may be utilized and structural changes may be made without departing from the scope of the present invention.

In general, the present disclosure discusses an apparatus that reduces windage-induced vibrations is a disc drive as seen at the heads that pass over the disc and read and write data to and from the disc. The apparatus includes a load beam including a leading section and a swage hole. The load beam also includes a trench arrangement. Flexible circuitry is housed within the trench. The apparatus also includes a plate that cooperates with the load beam to hold the flexible circuitry in the trench.

Disc Drive System

FIG. 1 is an asymmetric view of a disc drive **100** having structure in which principles of the present invention may be practiced. The disc drive **100** includes a base **102**, and a cover (not shown). Base **102** and the cover form a disc drive enclosure. Extending into base **102** is a spindle motor **106** to which several discs **110** are secured. Each disc **110** is generally angular in shape, with an inner edge **112** and an outer edge **114** circumscribing opposing disc surfaces **116** (of which only one is visible in the drawing) to which data can be stored for later retrieval. Base **102** provides a cavity or room for disc **110** to be seated in a substantially coaxial arrangement, with an inner wall **118** of the base running around outer edges **114** of disc **110**, substantially transverse to disc surfaces **116**.

On one side of a pivot **121**, an actuator assembly **120** includes a plurality of arms **122** to which are attached load beams or suspension assemblies **124**. At the end of each suspension assemblies **124** is a slider or head **126** that carries the read/write devices (designated generally by **128**). The present invention is equally applicable to sliders having different types of read/write devices, such as what is generally referred to as transducers, magneto resistive heads, giant magneto resistive heads, or tunneling magneto resistive heads. On another side of the pivot, actuator assembly **120** extends to support a voice coil **130** next to one or more magnets **132** fixed relative to base **102**. When energized, resultant electromagnetic forces on voice coil **130** cause actuator assembly **120** to rotate about pivot **121**, thereby bringing the read/write devices into various radio locations relative to disc surfaces **116**. It can be seen that, with spindle motor **106** rotating discs **110** for example, in a direction indicated by arrow **140**, and actuator assembly **120** moving read/write heads **128** in an arcuate path, as indicated by arrow **142**, across disc surfaces **116**, various locations on disc surfaces **116** can be accessed by the read/write heads for data recordation or retrieval.

As discs **110** are rotated, fluid or air adjacent to disc surfaces **110** is also brought into motion, generating air streams or flow currents in the disc drive enclosure.

This airflow, or windage, create forces both in direction **140** in the plane of disc surfaces **116**, as well as a direction normal to the plane of disc **116**. There also may be various other windage-induced forces occurring throughout the cavity provided by base **102** and cover **104**.

FIG. 2 shows a disc drive system **300** incorporating an example embodiment of a suspension assembly **324** mated to an interconnect assembly **344** of the present invention. Disc drive system **300** generally includes a disc **310**, an arm arrangement (shown generally as **311**), control circuitry **360** and interconnect assembly **344**. As is conventionally known, disc **310** contains magnetically encoded information and is rotated by a spindle motor. Arm arrangement **311** is supported above disc **310** by an actuator assembly that generally includes an actuator arm (not shown), a support arm (not shown), and a suspension assembly **324** supporting a head **322** (see **FIG. 3**). The actuator arm extends from an actuator and attaches to the support arm. The support arm extends from the actuator arm and is attached to suspension assembly **324**.

Referring to **FIGs. 2** and **3**, the disc drive system **300** includes a suspension assembly **324** having a load beam **364** and a gimbal portion **366**. Suspension assembly **324** supports head **322**, which is located on the gimbal portion **366** of the suspension assembly **324**, preferably by an adhesive such as glue or fluid epoxy. Alternatively, head **322** may be mounted to suspension assembly **324** by other conventional mounting methods well known in the art. Suspension assembly **324** cooperates with an arm (not shown), which is connected to the actuator arm (not shown), to resiliently support head **322** to allow head **322** to read and write data to the disc **310**.

As the disc drive system **300** operates, disc **312** rotates and induces airflow that includes a radial component (applied in a direction A shown in **FIG. 2**) and a tangential component (in a direction perpendicular to a primary surface of disc **310**). As a result of the combined components, strong currents are created, and the resulting airflow causes windage-induced vibration of the suspension assembly **324**. The effects of the windage-induced vibration cause the head **322** to vibrate, thus affecting the vertical

spacing between the head **322** and the disc **310** as well as the on-track stability of head **322**. The airflow impinges upon a windward, or leading edge **350** of the suspension assembly **324** and creates a turbulent wake on the leeward, or trailing, edge **352** of the suspension assembly **324**. An advantage of the present invention is that it reduces windage-induced vibration that affects the vertical spacing between the head **322** and the disc **310**, as will be discussed.

Disc drive system **300** also includes interconnect assembly **344** to complete the electrical connection between the head **322** and the control circuitry **360**. Preferably, the interconnect assembly **344** is a flex-on suspension, or flex circuit made from a polyamide substrate, with manufacturing techniques for flex circuits being well known in the art. Interconnect assembly **344** includes a head portion **341**, a tail portion **343**, and electrical conductors **346** (see **FIG. 3**) that extend from the head **322** to the control circuitry **360** and electrically transmits electrical signals between the head **322** and the control circuitry **360**. Preferably, the tail portion **343** extends along the leeward edge **352** of the suspension assembly **324**. **FIGs. 3** and **5A-F** show the tail portion **343** extending along an opposing side of the interconnect assembly **324** as compared to the arrangement shown in **FIG. 2**. However, this merely illustrates that the interconnect tail can be positioned on either side of the interconnect assembly depending on the orientation of the suspension assembly relative to the center of the disc, so long as the interconnect tail is on the leeward side.

Referring to the example embodiment shown in **FIGs. 5A-F**, the interconnect assembly **344** is mated to the suspension assembly **324**. The interconnect assembly **344** and suspension assembly **324** can be mated using a variety of techniques well know to one of skill in the art, for example, using glue or epoxy.

<u>Example Embodiment of Suspension and Interconnect</u>

To reduce windage-induced vibration, the present invention reduces the area of the interconnect assembly exposed to the air currents generated by disc rotation.

Referring to **FIGs. 3A-F**, an example embodiment of a suspension assembly mated to an interconnect assembly of the present invention is shown. The suspension assembly includes a top **370** (**FIG. 3B**), a core **372** (**FIG. 3C**), and a bottom layer **374** (**FIG. 3D**). Preferably, the suspension assembly **324** is formed from a laminate material, such as a laminate material made from, for example, layers of steel / poly / steel, which allows features to be created on the suspension assembly **324**, for example, by etching. Preferably, the top and bottom steel layers have a thickness in the range of about 20 to 70 μm, and the core layer has a thickness in the range of about 10 to 125 μm. In order to have sufficient room for the interconnect assembly **344**, the core layer, or at least the trench provided by core **372** and bottom layer **374** for the interconnect assembly, should have a thickness of at least about 50 μm.

The laminate material layers may be made a variety of different materials. For example, the top and bottom layers may include a metal or metal alloy, and the core layer may include a polymer material such as Kapton® film or other polyimide materials. The core layer may also include an adhesive type material or a material optimized to have high damping properties, such as visco-elastic adhesive.

The bottom layer **374** forms the base of the suspension assembly **324** and includes a trench **376** for interconnect assembly **344**. The core layer **372** is coupled, directly or indirectly, between the top layer **370** and the bottom layer **374**, and also includes a trench **377** arrangement (that preferably match trench **376**) that receives and houses a portion of the interconnect assembly **344** (see **FIG. 3E**). The top layer **370** preferably does not include a trench feature to promote capturing of the interconnect assembly **344** in the suspension assembly **324**.

A pair of PZTs **354**, **356** are typically mounted to a primary exposed surface **351** of top layer **370** (see **FIG.** 3) and oriented relative to certain features of a base plate **378** as shown in **FIG. 3F**. A second section **362** of the interconnect assembly **344** is connected to first and second PZTs **354**, **356**. The base plate **378** is typically positioned adjacent a surface of the disc **310**, although different stacking orientations are possible, and is used to mount the suspension **324** to the rest of arm assembly **311**.

Method Of Assembly

Referring to **FIGs. 4** and **5A-F**, one example method of forming a suspension assembly having an interconnect assembly with a reduced exposed area is illustrated. A sheet of stock material, for example, a sheet of laminate material or layers of a sheet of laminate material, may be etched **(400)** to form a load beam **(402)**. A trenching arrangement in the load beam may be preformed using techniques known to one of skill in the art. A gimbal assembly may be coupled to the load beam **(404)** using techniques known to one of skill in the art, such as welding or gluing. The interconnect assembly is then located in the trenching arrangement and secured into place **(406)**. The interconnect assembly is also electrically connected to the heads on the gimbal assembly. The interconnect is located between the base plate and the top layer of the load beam and a base plate is coupled to the load beam **(408)**. The PZTs may then be attached to the suspension assembly **(410)**. The outer portion of the interconnect assembly may then be folded over and welded to the PZTs **(414)**. A pre-load force may then be applied in the finished assembly **(412)** by adding a bend at a bend section of the load beam.

An advantage of the present invention is that it may greatly reduce vibration of the suspension assembly as measured at the head (a critical parameter for accurate data transfer between the disc and the head), thus reducing the introduction of errors due to windage-induced vibration. Another possible advantage of the present invention is that after the interconnect assembly is enclosed between the base plate and the suspension assembly, the enclosed portion of the interconnect is not exposed to further assembly tooling.

A yet further advantage of the present invention relates to the symmetry of the suspension assembly enabled by routing the interconnect in a trench of the laminate. Symmetry in the suspension assembly is typically one of the design objectives when creating a suspension assembly. Asymmetry in the suspension assembly invariably leads to resonance issues would not normally cause vibration problems in the suspension. For example, the bending modes of the suspension primarily move the suspension up and down without any side-to-side motion that would lead to off track motion of the head.

However, when there is asymmetry present in the suspension assembly, the otherwise normal up and down motion of the bending modes may begin to take on some side-to-side motion. Known suspension assembly designs that rout the interconnect along a side of the load beam are inherently asymmetrical, thus making them subject to possible resonance issues, as discussed above. The present invention increases the amount of symmetry in the suspension assembly by routing the interconnect assembly in a trench down the center of the suspension assembly.

It will be clear that the present invention is well adapted to attain the ends and advantages mentioned as well as those inherent therein. While presently preferred embodiments have been described for purposes of this disclosure, various changes and modifications may be made which are well within the scope of the present invention. Numerous other changes may be made which will readily suggest themselves to those skilled in the art and which are encompassed in the spirit of the invention disclosed and as defined in the appended claims.